Clean Slate Environmental Remediation DSA for 10 CFR 830 Compliance

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Keywords: environmental restoration, hazards analysis, controls, 10 CFR 830

Abstract

Clean Slate Sites II and III are scheduled for environmental remediation (ER) to remove elevated levels of radionuclides in soil. These sites are contaminated with legacy remains of non-nuclear yield nuclear weapons experiments at the Nevada Test Site, that involved high explosive, fissile, and related materials. The sites may also hold unexploded ordnance (UXO) from military training activities in the area over the intervening years. Regulation 10 CFR 830 (Ref. 1) identifies DOE-STD-1120-98 (Ref. 2) and 29 CFR 1910.120 (Ref. 3) as the safe harbor methodologies for performing these remediation operations. Of these methodologies, DOE-STD-1120-98 has been superseded by DOE-STD-1120-2005 (Ref. 4). The project adopted DOE-STD-1120-2005, which includes an approach for ER projects, in combination with 29 CFR 1910.120, as the basis documents for preparing the documented safety analysis (DSA). To securely implement the safe harbor methodologies, we applied DOE-STD-1027-92 (Ref. 5) and DOE-STD-3009-94 (Ref. 6), as needed, to develop a robust hazard classification and hazards analysis that addresses non-standard hazards such as radionuclides and UXO. The hazard analyses provided the basis for identifying Technical Safety Requirements (TSR) level controls. The DOE-STD-1186-2004 (Ref. 7) methodology showed that some controls warranted elevation to Specific Administrative Control (SAC) status. In addition to the Evaluation Guideline (EG) of DOE-STD-3009-94, we also applied the DOE G 420.1 (Ref. 8) annual, radiological dose, siting criterion to define a controlled area around the operation to protect the maximally exposed offsite individual (MOI).

Introduction

Clean Slate II and Clean Slate III are two of the 1963 Operation Roller Coaster sites. Operation Roller Coaster (Ref. 9) consisted of four test shots designed to explore the dispersal of material from a non-nuclear yield explosion of a nuclear weapon inside a concrete structure. The four tests are Clean Slate I, II, III, and Double Tracks. The quantities of plutonium involved in each of these tests exceeded the hazard category 2 (HC2) threshold. Clean Slate II and III also included depleted uranium. Environmental remediation (ER) has previously been performed on the Clean Slate I and Double Tracks sites. The Clean Slate II and III sites enclose 68,400 and 81,500 m^2, respectively, and have received some remediation in the past. At the initiation of this project, the sites had widespread, low-level contamination throughout their areas.

Clean Slate II and III are located on the Tonopah Test Range (TTR), adjacent to the Nevada Test Site (NTS). Various environmental studies have been performed on the TTR, which eventually prompted a corrective action investigation (CAI). The CAI culminated in a proposed remediation action cleanup plan that was approved by the Nevada Division of Environmental Protection. This plan calls for the two sites to be remediated to a contamination level of less than 1,000 pico Curies per gram (pCi/g) of soil and debris (with no 9 m^2 area exceeding 3,000 pCi/g). This amounts to an estimated 68,400 and 17,900 m^3 of soil and debris to be removed from Clean Slate II and III, respectively. These volumes represent estimates of material to be removed from higher specific activity ground zero (GZ) and plume regions, in addition to lower specific activity surrounding areas.

As the tests performed at the sites involved greater than HC2 quantities of nuclear material and integral estimates of contamination levels show a greater than HC2 quantity of nuclear material, the sites fall within the realm of 10 CFR 830, which defines specific requirements to assure safe operations.

In a passive state, the contamination at the sites is widespread, such that no single event can mobilize a significant portion of the inventory and subject it to potential release. In contrast, remediation operations will process the majority of the site inventory, thereby subjecting it to potential release and subsequent exposure of onsite and offsite personnel. As such, remediation operations fall under the purview of 10 CFR 830.

Regulatory Setting

Regulation 10 CFR 830 identifies DOE-STD-1120-98 and 29 CFR 1910.120 as the safe harbor methodologies. DOE-STD-1120-98 has been superseded by DOE-STD-1120-2005. As such, the project adopted DOE-STD-1120-2005, which was in draft version when this work was initiated. To securely implement the safe harbor methodology, we also applied DOE-STD-1027-92 and DOE-STD-3009-94 as needed to develop a robust hazard classification and hazards analysis. The hazards analysis provided the basis for identifying TSR level controls. The DOE-STD-1186-2004 methodology showed that some controls warranted elevation to SAC status. Potential accident events were assessed using the DOE-STD-3009-94 EG.

The 10 CFR 830 methodology brought several unexpected observations. The analysis showed that the greatest unmitigated radiological hazards were potentially from cumulative fugitive emissions of normal operations and not from single accidents per se. This followed from the integrated effect of fugitive dust emissions from excavating, scraping, and other operations. With this realization, we recognized a need to include an MOI EG that would be appropriate for assessing long-term emissions. As DOE-3009-94 limits exposure periods to two hours, it was not deemed appropriate for assessing longer term exposures. The DOE G 420.1 siting criterion annual dose guideline was selected for this application.

Analysis Scope

This remediation effort was unusual in the sense that an HC2 level of material would be processed during the remediation operations. Ordinarily, a DSA and formal accident analysis is appropriate for an HC2 facility. However, the nature of the work would not involve sophisticated process operations or equipment and contamination levels of the soil and debris to be processed would be low. As such, application of a formal accident analysis seemed inappropriate. This issue was assessed, resulting in an agreement between the DOE and M&O contractor that a hazards analysis would provide an appropriate level of analysis for the DSA. The HC2 level of hazard also called for TSRs to help assure safe operations. The TSRs could include SACs as necessary, per DOE-STD-1186-2004. Thus, the decision was mutually cast to develop a DSA using a hazards analysis to provide a basis for TSRs with SACs as required.

Remediation Operations / Activities

The Clean Slate II and III operations are defined by seven distinct operational tasks. These are:

- UXO Clearance
- Site Mobilization
- Site Excavation
- Segregate, Sort, and Package
- Waste Loading, Transportation, and Disposal
- Decontamination
- Confirmation Sampling and Demobilization

UXO clearance is the process of surveying an area for unexploded ordnance (UXO) or high explosive (HE). This activity is performed prior to operations in an area. As ordnance and HE may be present on or below the surface, ordnance or HE that escaped detection during a pre operation survey may be discovered during operations. Thus UXO clearance may be performed both prior to and during an operation.

Site mobilization is the process of preparing a site for operations. It includes erecting office and other support facilities, putting in roads, constructing work pads, establishing work zones, bringing equipment onto site, etc.

Site Excavation involves excavating and stockpiling soil and debris for processing. Large debris may be size-reduced as needed. Interim soil samples will be collected during excavation activities to identify whether excavation is complete. Dust suppression will be performed using water trucks or other techniques as appropriate.

In the Segregate, Sort, and Package operation, stockpiled soil and debris will be segregated and sorted using a hopper, conveyor, shaker tables, or other means. The material will then be packaged into waste sacks or B-25 boxes.

In Waste Loading, Transportation, and Disposal, waste packages will be documented and transported for final surveys. The packages are then transported to Area 3 of the NTS for disposal.

Decontamination operations will be performed routinely during much of the remediation operations. Throughout the ER process, personnel, equipment, vehicles, and other items will be decontaminated prior to leaving the exclusion zone. Contaminated water will be recycled, and contaminated materials will be disposed, as appropriate.

Confirmation Sampling and Demobilization is the key path to closure. At the conclusion of excavation activity, samples will be collected to ensure that the site has been remediated to project level goals ($\leq$1,000 pCi/g). Excavations will be backfilled and facilities and equipment will be demobilized back to the NTS or to another site.

Worker Consequence / Risk Estimates

Objectives of the hazards analysis are to identify nuclear and non-standard industrial hazards and to identify means to control those hazards to acceptable levels. Hazard consequence and risk levels are presented as qualitative measures, commensurate with the scope of a hazards analysis. Qualitative levels are assigned with the aid of scoping assessment algorithms to help assure appropriate, self-consistent, consequence level assignments.

For immediate and co-located workers, the hazards analysis addresses nuclear and non-nuclear non-standard industrial hazards. The DSA also includes a section that identifies standard industrial hazards (SIH) that can result in serious worker consequences. These fall under the categories:

- Radiological
- Chemical
- Physical
- Biological
- Fire / Explosion
- Other Potential Hazards

These SIHs are included in the DSA to help assure their inclusion in more specific site hazard control documents. The site specific hazard control documents provide the formal tie to 29 CFR 1910.120 requirements. It is noteworthy that DOE-STD-3009-94 defines SIHs as “those hazards that are routinely encountered in general industry and construction, and for which national consensus codes and/or standards (e.g. OSHA, transportation safety) exist to guide safe design without the need for special analysis to design safe design or operational parameters.” As such, encountering ordnance or HE at a job site is a non-nuclear hazard that is not considered a standard industrial hazard. Thus, UXO and HE fragments are analyzed in the process hazards analysis (PrHA) as non-nuclear non-standard industrial hazards. These hazards are also identified in the discussion of SIHs, for there are aspects and lesser consequence scenarios associated with these materials that are representative of SIHs, such as limited reactive response and toxic qualities.

The approach for identifying and analyzing hazards in the DSA is:

- Identify hazards using a Hazard Identification table - energy sources, etc.
- What If Tables
- Group What If table scenarios
- Process Hazards Analysis

While specific implementations of these activities vary with regard to details, the general implementation is consistent with standard process safety practices. A hazard identification table was developed specifically for the requirements of this project. The What If Tables follow a fairly standard format with fields for the scenario number, accident type, initiating event and scenario, consequence, and comment or action. The PrHA tables were specifically developed to allow each table to show potential consequences and risk associated with each of the contamination ranges of soil expected to be encountered. The PrHA tables provide the means for developing controls and show consequence and risk measures with and without controls implemented.

The types of accidents that were identified for the seven operations include:

- walking on contaminated soil
- physical impact to soil or debris
- free fall of soil/debris (spill)
- fires
- deflagration with and without fire
- ordnance or HE detonation
- high pressure gas impingement on soil/debris
- wind resuspension
- flood
- airplane accident
- impact and explosion of ordnance (e.g., from offsite training activities)

These accident classes were analyzed using a variety of techniques deemed appropriate for the scenarios at the level of sophistication of a hazards analysis.

Consequence Analysis Approach

Consequences for individual PrHA scenarios are estimated using a semi quantitative bounding approach. This permits consequences for each scenario to be assessed in a uniform manner reflecting the phenomenology of the scenario. This approach is applied with a level of rigor suitable for scoping assessments.

Internal exposures to workers are estimated using either agricultural based fugitive dust generation rate data or applications of release data to material at risk (MAR) estimates. Each approach provides an airborne concentration of respirable soil/debris associated with the scenario. The worker is exposed to this mass concentration for a given time, deemed appropriate for the scenario.

A conservative ten-minute exposure time is used as a bounding value for instantaneous release scenarios, such as spills, impacts, and explosions. An eight-hour exposure time period is used for fire and high wind scenarios. An annual exposure dose is estimated for situations that can persist for longer periods such as vehicle dust, dusty operations, or excessive dust generation in process equipment. The annual exposure time is estimated using an approximate duty factor for the fraction of time the worker will be exposed to different activity soils, with allowance made for preparation time. In the case of an aircraft accident scenario, a ten-minute exposure time is used for the impact release component and an eight-hour exposure time is used for the fire component. A one-hour exposure time is used for a high rains with flooding scenario, for after one hour the area is deemed sufficiently wet, such that aerosol generation rates of soil/debris are greatly reduced.

A moderate activity breathing rate of 3.4×10^{-4} m^3/s is used to estimate the quantity of soil/debris aerosol inhaled by workers exposed to airborne concentrations of hazardous material. The specific activity of the soil/debris is applied to the mass inhaled to obtain a radioactivity burden. A committed dose, in rem, is estimated by applying a dose conversion factor of 3.3×10^{8} rem/Ci, deemed suitable for aged weapons plutonium, to the activity burden.

Estimated worker exposures in rem, are assessed against evaluation guidelines, to bin the consequence estimates into qualitative categories. These qualitative consequence bins are used with qualitative frequency assignments to establish estimated qualitative risks for each scenario. A summary of events, release data, exposure concentrations, and references used for most scenarios are presented in Table 1.

Agricultural Based Release Models

In some ways, agricultural operations mimic the proposed environmental remediation operations. Mechanized operations are performed on surface soils over large areas. These operations are also accompanied by the generation of fugitive dusts. Data (Ref. 10) presented in the literature provide generation rates for fugitive dust particulates that are 10 microns and smaller (PM_{10}). These data are presented as mass based emission factors for an acre of soil treated by various agricultural operations. Operations include list and fertilize, roll, terrace, chisel, plow, float, and land plane.

Emission factors are used to define a concentration of hazardous material present in the vicinity of the immediate worker. This is accomplished by recognizing that these data give masses of material emitted through various treatments of an acre of land. Concentrations are estimated by placing these masses into a well mixed, four meter high, control volume covering the area treated. The result is an immediate worker exposure concentration estimation for that operation.

In this analysis, it is assumed that emissions for general environmental remediation operations, such as scraping and grading, can be approximated by releases for agricultural plowing operations. The datum gives an emission factor of 1.2 pounds per acre processed. Mixing this emission factor into a hypothetical four meter high control volume covering an acre gives an airborne concentration of 3.4×10^{-2} g/m^3 for near field operations representative of plowing.

An estimate for the internal exposure to a person walking over soil/debris is obtained using agricultural data for fertilizing operations. The fertilizing operation is selected as it impacts the land surface less than other operations listed. A person's footfalls are deemed to impact the land surface far less than farm machinery. The fertilizing datum is linearly adjusted to recognize that a fertilization operation over a square meter of area treats 100 percent of the land area, whereas a person walking over the same square meter, in passing, only impacts a fraction of the land area as defined by the person's footsteps. The selected datum (Ref. 10) for fertilizing gives an emission factor of 0.8 pounds per acre processed. Placing this emission into a control volume and adjusting for foot print coverage provides an airborne exposure concentration of 2.1×10^{-3} g/m^3. This concentration is further reduced by an order of magnitude to recognize that a person weighs less and impacts the ground significantly less than farm machinery, thereby giving an estimated near field airborne concentration of 2.1×10^{-4} g/m^3.

An exposure concentration associated with heavy rains causing flooding is also estimated using an emission factor for fertilizing. The emission factor of 0.8 pounds PM_{10} released per acre into a well mixed four meter high control volume over the area is used to estimate a concentration of 2.3×10^{-2} g/m^3.

In the higher radioactivity areas, such as the GZ area, a significant amount of contamination is attached to aggregate structural debris. As such, a release from such debris is expected to be significantly lower than for contaminated soil. The MOI dose estimate included contributions from powdered and aggregate source materials.

DOE-HDBK-3010-94 Based Models

The "DOE Handbook, Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities," (DOE-HDBK-3010-94) (Ref. 11) provides release data for a wide assembly of experimental situations. These data were used to develop release estimates for:

- Ordnance detonation in soil/debris
- Fire over soil/debris
- Deflagration with fire
- Physical impact into soil/debris
- Gas impingement into soil/debris
- Resuspension of soil/debris by wind
- Soil/debris spill

Ordnance detonation in soil is assessed using Handbook data for shock impact to soil. Releases from fires over soil/debris use airborne release fraction (ARF) and respirable fraction (RF) data for thermal stresses to powders with a damage ratio (DR) of 0.1. For fires, a 5 cm burn depth, necessary to estimate the MAR, is taken from forest fire data (Ref. 12) reported in the literature. Deflagration with fire sums the methods used for explosion and fire.

Material releases due to physical impacts to soil/debris use bounding data cited in the Handbook (DOE-HDBK-3010-94) for impacts to powders. For lifted objects, the impact area is taken to be one m^2 with an impact depth of six inches. For overturned heavy equipment the impact area is taken to be 10 m^2 with an impact depth of six inches. In the case of the aircraft accident, the analysis employs both a physical impact component and a fire component. The aircraft impact area is taken to be 5000 m^2 with an impact depth of 1/3 m. Material release for a high pressure gas impingement into soil/debris uses bounding Handbook data cited for venting a pressurized gas through powder. One pound of soil is assumed impacted. The release model for resuspension by wind uses a bounding handbook resuspension factor for plutonium at the Nevada Test Site. The release for a soil/debris spill uses a bounding Handbook ARF and RF for a free fall spill of powder.

Source terms for postulated accident scenarios are estimated using the Five-Factor Formula described in DOE-HDBK-3010-94.

For fire, spills, impacts, and gas impingement, the source term is estimated by applying the appropriate ARF and RF to an estimated MAR for the scenario under study. For explosions, it is the material driven airborne by the event, as described using the correlation provided in DOE-HDBK-3010-94. For material re-suspended by high winds the resulting airborne concentration is estimated using the resuspension factor and relationship provided in DOE-HDBK-3010-94.

For fires, the exposure concentration is estimated by releasing the source term into a 30m high, well mixed control volume, covering the fire area.

For explosions, the exposure concentration is estimated by releasing the source term into a well mixed conical control volume defined by the cloud top height and the plume radius. The cloud top height and plume radius were estimated from correlations (Ref. 13) using a 500 pound TNT equivalent explosion. The cloud top height defines the height of the cone and the plume radius defines the radius at the base. A 65 pounds per square inch (psi) peak overpressure is recognized as a threshold for 100 percent fatalities and 5 psi is a recognized threshold for ear drum rupture[14]. A correlation relating peak overpressure to distance and yield (Ref. 14) is used to estimate distances for fatalities and significant injuries. As the area near the explosion is fatal, no radiological consequences are shown, for non-radiological effects dominate.

Deflagrations were analyzed as a shock component to soil/debris followed by a fire component. The radionuclide release is the combined contributions from an explosion and an accompanying fire. The TNT equivalent of the deflagration is estimated using a heat of combustion and an explosion yield factor (Ref. 15). These data showed the deflagration explosion yield to be bounded by the UXO explosion. The deflagrations were treated as the sum of the UXO explosion (as a bounding value) and an eight-hour fire.

For spills and impacts, the exposure concentration is estimated using a steady state approximation for a control volume that considers of a cross sectional area in concert with a cross wind.

One observation that arose from these analyses is that accident events involve single instances of spilling contaminated soil or debris. These single events pale in comparison to the cumulative effects from fugitive releases associated with moving the entire inventory of soil and debris over the operational period. As such, we recognized a need to complement the assessment of single event consequences with potential consequences associated with processing the entire inventory of soil and debris. As the DOE-STD-3009-94 EG is for a two-hour exposure period associated with single events, it was not deemed suitable for an assessment of the cumulative annual effect of normal operations. As such, the project turned towards the DOE G 420.1-1 siting criterion of 25 rem total effective dose equivalent (TEDE) delivered over a one year period. That brought the observation that unmitigated operations, that is operations without specific dust suppression, could challenge the annual EG with the site boundary initially envisioned, that could place the maximum exposed offsite individual as close as 50 m to the operation. Moving the controlled area out to just 100 or 200 m dropped the potential dose to the MOI sufficiently so that a challenge to the annual EG was no longer a concern for normal unmitigated operations.

Maximally Exposed Offsite Individual

The nature of the outdoor remediation operations indicated that two types of exposure analyses would be needed to appropriately assess doses to the MOI. These are a short term release associated with a maximum consequence event and a longer term exposure representative of unmitigated operations. A maximum event in the form of an aircraft accident involving a staging pile was selected as a maximum consequence, single exposure event. For a longer term exposure, an estimate of the total volume of soil and debris to be processed was used with a release fraction to estimate an unmitigated airborne source term. This source term was used with a dose to source ratio to estimate the MOI annual dose. The dose to source ratio was estimated using site specific parameters in the MACCS code (Ref. 16).

The cumulative dose from the fugitive operations associated with processing soil and debris is a fixed value, determined by the volume of soil and debris processed. As such, the annual exposure to fugitive emissions drove the specification of a controlled distance from the operations, such that annual doses would not challenge the DOE 420.1-1 siting criterion. Originally, the MOI might be as close as 50 m. However, these analyses showed that a clear argument could be presented that the EG would not be challenged under unmitigated conditions if the controlled distance to the MOI would be on the order of 200 meters.

With the distance to the MOI specified, assessment of a maximum event permitted a MAR to be specified such that potential exposure to a single event would be within the DOE-STD-3009 EG. As the maximum event was identified to be an aircraft accident involving a staging pile, this assessment permitted the specification of MAR limits for staging piles. No other single event was identified with the potential for as great a point source as the aircraft accident.

Conclusion

The DSA developed for the Clean Slate II and III remediation operations showed that these operations could be performed safely and that safety was assured through application of straightforward controls such as dust suppression, controlling the MOI distance, and various aspects related to UXO and nearby aerial exercises using live ordnance.

Comparison of annual emission estimates to the DOE G 420.1-1 siting criterion showed that the original anticipated nearest point of public access was too close. This caused a reevaluation of the extent to which the area surrounding the operation must be controlled. Initially public access could be as close as 50 m. Analyses showed that significant gains could be realized by simply extending the controlled area out to 100 to 200 m (using DOE-STD-3009 methodology). Analyses also showed that the potential presence of unexploded ordnance (UXO) and high explosive (HE) fragments posed a significant worker hazard that required control.

The 10 CFR 830 analysis provided several obvious benefits. One that came to light early in the analysis is the significance of the dust control program to worker safety. Another is the magnitude of the hazard presented by UXO and legacy HE that might be present on site. Another functional benefit is that the DSA will provide the project with a basis to justify shedding controls when not necessary, thereby contributing towards efficiency and greater resource management.

The analysis of nuclear and non-standard non-nuclear hazards showed that a dominant worker hazard was potentially associated with UXO, HE, and errant ordnance. As such, programmatic controls were specifically identified to help assure that these risks are managed accordingly.

Table 1. Exposure Concentrations for Activities and Events

Event/Activity	Release Data	Reference	Concentration g/m^3
General Remediation Operations on Soil/Debris	1.2 lb per acre (Emission Rate for Plowing/Tilling)	Gaffney and Yu[10]	3.37×10^{-2} (for 4 m high control volume)
Walking on Soil/Debris	0.074 lb per acre (Emission Rate for Fertilizing as modified by fractional foot print coverage and impact)	Gaffney and Yu[10]	2.09×10^{-4} (for 4 m high control volume and two 1/2 ft^2 foot prints per m^2)
Ordnance Detonation	ARF = .8 x TNT equivalent in kg RF = .25	DOE-HDBK-3010-94[11] ARF, p. 4-62 RF, p. 4-62	2.13×10^{-2} (500 lb TNT equivalent, 2.13×10^{6} m^3 volume)
Deflagration (without fire component)	ARF = .8 x TNT equivalent in kg RF = .25	DOE-HDBK-3010-94[11] ARF, p. 4-62 RF, p. 4-62	5.59×10^{-3} (2.35 lb TNT equivalent, 3.82×10^{4} m^3 volume)
Fire	ARF = 6×10^{-3} RF = 1×10^{-2} Burn Depth = 5 cm	DOE-HDBK-3010-94[11] ARF, p. 4-56 RF, p. 4-57 Bruce M. Kilgore - Burn Depth[12]	1.5×10^{-2} (DR = 0.1 with 5 cm burn depth and 30 m high control volume)
Physical Impact to Soil/Debris	ARF = 1.00E-3 RF = 0.1	DOE-HDBK-3010-94[11] ARF, p. 4-87 RF, p. 4-87	3.81×10^{-3} (1 m^2 impact area, 0.15 m impact depth, 1 m/s wind, and 10 m^2 ventilation area)
High Pressure Gas Impingement Into Soil/Debris	ARF = 0.1 RF = 0.7	DOE-HDBK-3010-94[11] ARF, p. 4-71 RF, p. 4-71	5.3×10^{-3} (for 1 lb soil/debris MAR, 1 m/s wind, and 10 m^2 ventilation area)
Wind Resuspension	Resuspension Factor = 3.00×10^{-9} m^{-1}	DOE-HDBK-3010-94[11] Resuspension Factor, p. 4-91	4.50×10^{-3} (for 1 cm depth MAR)
Flooding	0.8 lb per acre (Emission Rate for fertilizing)	Gaffney and Yu[10]	2.25×10^{-2} (for 4 m high control volume)
Free Fall Soil/Debris Spill – contaminated soil (powder like)	ARF = 2.00×10^{-3} RF = 0.3	DOE-HDBK-3010-94[11] ARF, p. 4-82 RF, p. 4-82	4.54×10^{-2} (for 1000 lb soil/debris spill, 1 m/s wind, 10 m^2 ventilation area)

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Mr. Space has 20 years of experience in environmental remediation and waste management projects and other environmental studies. His work includes safety basis documentation for Hazard Category 2 and 3 facilities, hazard analyses and safety control identification, and development of TSRs. Mr. Space has assisted in preparing safety basis documentation at DOE sites across the complex, and has worked extensively with DOE-STD-1120-2005 (and its precursor 1120-98). Mr. Space is currently a senior environmental scientist with OMICRON Safety and Risk Technologies in Albuquerque, New Mexico.

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Dr. Restrepo has provided engineering support to DOE/HQ in preparing DOE orders, standards, and guidance in design, safety, and risk analysis; in reviewing SARs/TSRs; and in performing numerous confirmatory analyses. Dr. Restrepo has supported the preparation and development of over five-dozen authorization basis documents (e.g., SARs and TSRs.). He led evaluations of computer codes/models on fires, explosions, spills, in-facility transport, and consequence analysis, as well as the development of life cycle costs and economic studies. He has developed and taught courses on PRA, consequence modeling, fire modeling, and reliability analysis. Dr. Restrepo is currently supporting DOE M&O sites with specialized expertise on nuclear safety and authorization basis, confirmatory analysis, and related issues (e.g., operational/safety assessments, reliability analyses, and weapons response evaluations for SNL, LANL, Pantex, Y-12, and NTS). He is providing technical advisory support to DOE field and area offices on operational readiness/safety program assessments, nuclear explosive safety, and risk-cost/benefit evaluations.

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Mr. Traynor has over 8 years of environmental restoration and other environmental studies experience. His background includes the development and approval of closure documentation for chemically and radiologically-impacted sites as well as the planning, execution, organization coordination, and oversight of environmental site closure. Mr. Traynor holds a Bachelor of Science in Engineering (BSE, Civil) from the University of Nevada, Las Vegas and is also Engineer in Training certified. Mr. Traynor is currently a Senior Engineer Task Manager for the Soils Project with Bechtel Nevada, the M&O contractor for the DOE/NSO NTS facility in Las Vegas, Nevada